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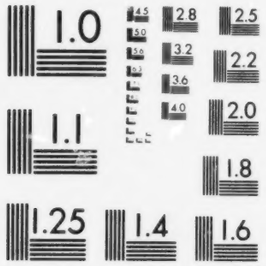


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TP 4216E

# A PRELIMINARY SYSTEM SPECIFICATION

# FOR THE

# ICE HAZARD DETECTION/COLLISION AVOIDANCE SYSTEM

By

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Viatec Resource Systems Inc.
Calgary, Alberta

November 1982

PREPARED FOR THE

TRANSPORTATION DEVELOPMENT CENTRE

TRANSPORT CANADA

The content of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre of Transport Canada.

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17. Abstract: An investigation conducted during the period of September 1982 to November 1982 to outline the capabilities of various sensors and the requirements of offshore operators is reported. These capabilities and requirements were utilized to produce a preliminary system specification for an integrated ice hazard detection/collision avoidance system (IHD/CAS). This system is to comprise a group of sensors designed to complement each other's performance. They range from long-range high frequency radar, medium-range microwave radar to relatively short range, low light level television systems and infrared detection systems. All sensors are to be fully integrated to permit the operator to gain all necessary ice detection information using one system and to enable the collision avoidance system to determine, with a high degree of confidence, the risk posed by ice present in surrounding water. A follow-on project will further elaborate the requirements for IHD/CAS and define to a much greater degree all of the various system specification requirements.

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17. Résumé

Ce rapport rend compte de l'étude faite entre septembre et novembre 1982 pour définir, d'une part, les aptitudes des divers types de détecteurs et, d'autre part, les exigences formulées à leur égard par les principaux intéressés que sont les navigateurs et les exploitants de plates-formes de forage en mer. Ces aptitudes et ces exigences ont permis l'élaboration d'un avant-projet de devis descriptif d'un système intégré de détection et d'évitement des glaces flottantes. Cet avant-projet prévoit un système comportant un ensemble de détecteurs étudiés de manière que l'action de chacun complète et renforce celle des autres: radar haute fréquence et longue portée, radar à hyperfréquences de moyenne portée, télévision sous faible éclairage et de courte portée et détection à l'infrarouge. En combinant tous ces moyens électroniques en un tout intégré, il devrait être possible d'obtenir un système capable non seulement de repérer la présence de glaces flottantes, mais aussi de fournir à l'utilisateur des données fiables sur leur évolution probable et sur le danger qu'elles peuvent représenter. Ultérieurement, il est prévu d'affiner davantage les caractéristiques du système étudié et de cerner de plus près les paramètres définis dans le devis descriptif.

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## 1.0 INTRODUCTION

Increased demand for oil and gas has pushed exploration and development into hostile environments such as the Canadian East Coast offshore areas and the High Arctic. In order to fulfill the objectives of the National Energy Policy, these sources of energy will need to be tapped.

Discoveries of major oil and gas fields such as the Hibernia field and the Beaufort Sea fields, have prompted the oil industry to seriously consider development of new techniques to allow year round operations. For example, the industry expects to move LNG from arctic islands through the Labrador Sea by 1987.

Such activities require the capability of furnishing the needed information and data on sea ice. Ice data is required for the design of platforms and facilities for navigational purposes, as inputs to ice forecasting models, for planning the day to day operations of all offshore activities including drilling, production and transportation. Extending the operational season with increased safety is perhaps one of the most critical aspects of improving the oil and gas profitability in ice-infested areas.

The general consensus of ice experts in industry, government and academic institutions is that remote sensing packages for on-site field and aircraft use should be developed. It is realized that shipborne remote sensing systems would be preferred, that all weather capability is an operational necessity, and that the detection of small icebergs and growlers is a priority.

As the first phase towards the development of an all weather system in response to industry needs, Viatec has been tasked by the Transportation Development Centre to conduct an investigation and prepare a preliminary system specification of an integrated Ice Hazard Detection and Collision Avoidance System (IHD/CAS). The specification provides performance targets, which have been reviewed with potential system development organizations.

## 2.0 JUSTIFICATION FOR IHD/CAS

Discussions with various groups (App. C) have shown that there is a general belief that no one sensor will be the solution to all detection problems, nor will any particular combination of sensors suit all user requirements. There exist three basic system requirements to suit the three general types of operating platforms requiring IHD/CAS systems.

The general IHD/CAS requirements include detection of hazards in sufficient time to avoid impact with ice hazards and other vessels or to take advantage of paths of least resistance through the ice. Sensors employed must be effective under all environmental conditions, including darkness, fog, heavy precipitation, and heavy sea states. Real time presentation of the information on some form of integrated display is necessary in a clear and concise form. Suggested tracks to avoid hazards or to predict ice movement should be displayed.

The economic viability of the shipping systems utilizing and IHD/CAS depends on minimizing trip transit times and fuel consumption, while maximizing ship environmental safety. For stationary platforms, the use of IHD/CAS is expected to result in reducing the occurrence of premature and unnecessary shutdown of operations and extension of operating seasons. Routine collection of reliable ice data could result in establishing data bases to aid in reducing the cost of overdesigned platforms and in planning operations. The most obvious benefit from the development of an IHD/CAS would be the increased safety from ice related accidents. With sufficient advance notice of the presence of dangerous ice formations, operators could arrange for the interception and deflection of the ice, or could take appropriate evasive action.

### 2.1 Definition of the Problem

The Canadian offshore environment is hostile to man, his machines and his works, and yet is also delicate, easily damaged and in the case of the arctic, slow to heal.

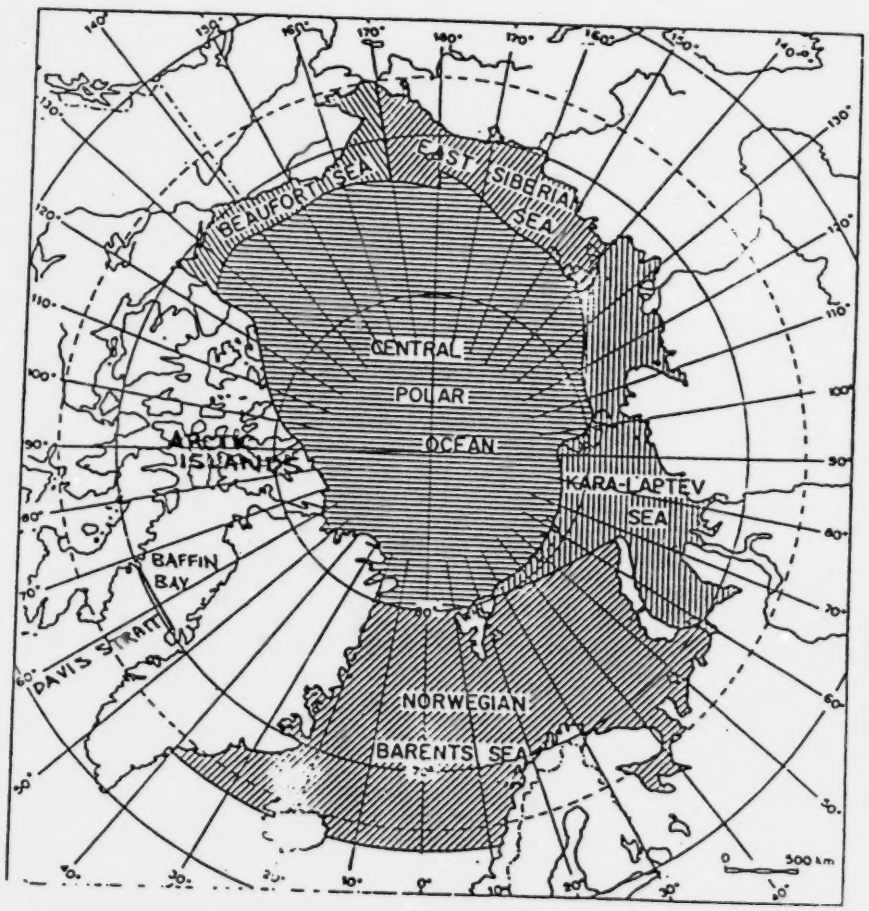
The parameters characteristic of those areas in which users will operate are:

sea ice in its various forms
icebergs, bergy bit and growlers
sea state
visibility
other ship traffic

## 2.1.1 Sea Ice

The greatest concentration of sea ice is to be found in the Arctic regions (Fig. 1). The Polar Ocean comprises the Arctic Ocean (shaded area in Fig. 1), less the Norwegian Sea, but includes peripheral seas such as the Beaufort Sea. For purposes of this study, the Arctic Islands area (Canadian Archipilego), Baffin Bay and Davis Strait are to be considered peripheral seas as well. The central Polar Ocean is an area where less than 10 per cent open water is found in summer. Although the central Polar Ocean suffers from extensive ice coverage year round, it is of little interest commercially. The peripheral seas contain the energy sources currently being explored. These areas also have winter ice cover, but have greater than 10 per cent open water in summer. Therefore an ice detection system is of use in these areas.

FIGURE 1




ARCTIC REGIONS

In the Arctic regions, new sea ice begins forming in late September or early October (1). Growth continues through April, attaining a maximum thickness of about 1.8 metres. Breakup in Lancaster Sound and Viscount Melville Sound may not be complete until July. Sea ice which survives several summers' melt is termed multiyear ice. The almost complete absence of salt from this ice makes it much harder than first-year ice, resulting in increased hazard and resistance to ship traffic.

In the Beaufort Sea, breakup commences in June. In September, during the greatest period of open water, pack ice comprises approximately 25 per cent of total surface area.

Concentrations of multiyear ice throughout Parry Channel are relatively low, averaging perhaps ten per cent. A lead along the extreme northern limit of this channel is present for much of the year.

In Baffin Bay and Davis Strait, the vast expanse of water results in considerably greater motion of the ice. Maximum thickness of ice here is 1.2 metres. However, small pieces of multiyear ice in conjuction with icebergs, bergy bits and growlers present hazards. Most of the icebergs originate from glaciers along the western coast of Greenland. The iceberg production rate is approximately 20,000 to 50,000 icebergs per year, with an average draft and mass of 100 m and two to four million metric tons respectively (2).

As one progresses south along the east coast, the amount of multiyear ice decreases, and ice eventually becomes entirely first year ice. Freeze-up begins in late December and breakup commences in March or April. Although not as threatening as the more northern ice fields, the rafting and ridging is extensive and results in a great number of potentially hazardous situations where relatively low powered vessels encounter ice frequently.

### 2.1.2 Icebergs, Bergy Bits and Growlers

Icebergs, which are massive pieces of ice of greatly varying shape, have a height of between 5 and 100 metres above sea level, and their smaller relatives, bergy bits and growlers, have presented hazards to ship navigation for many years.

Their detectability is a function of range, target size and shape, visibility, sea state and sensor used.

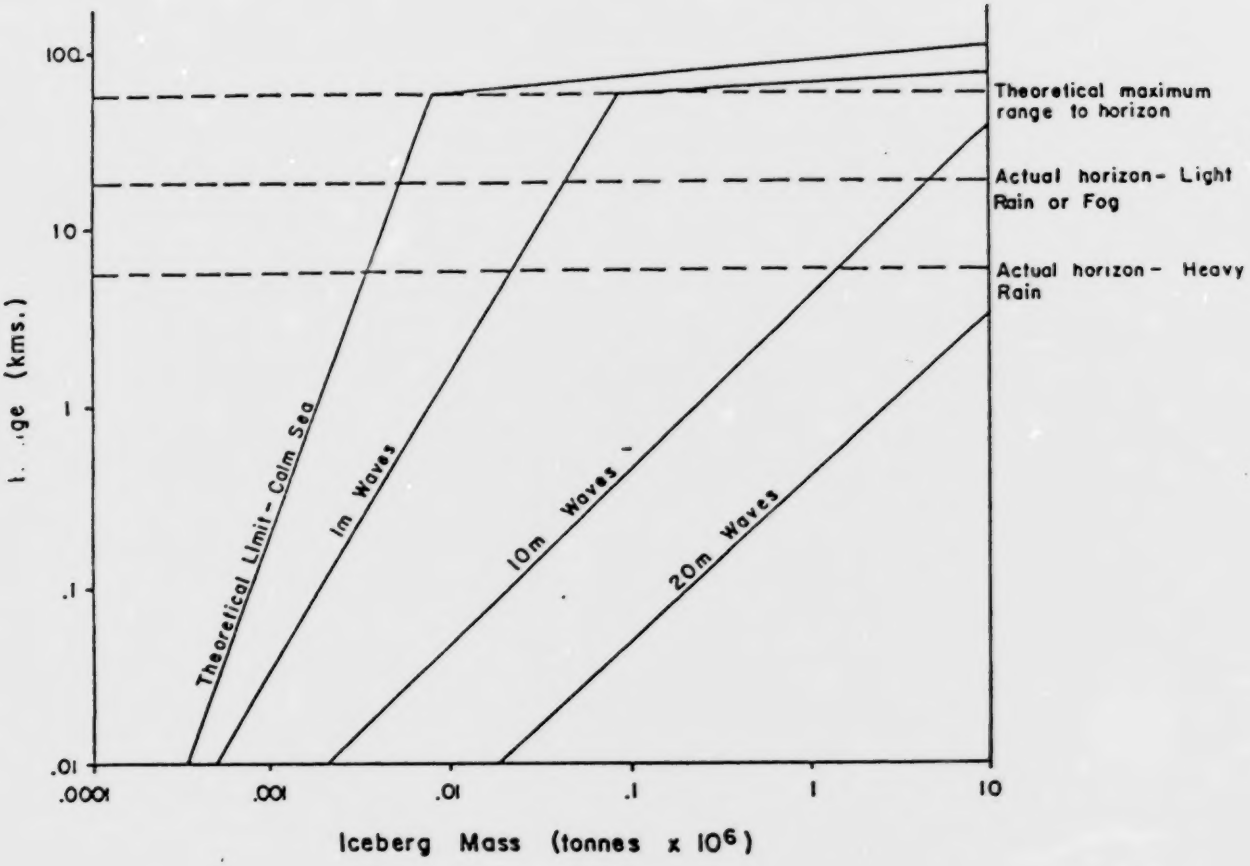
The ice hazard detection sensor performance chart in Figure 2 is a sensor specific model that can be used to predict ranges at which an average iceberg of a certain mass can be expected to be detected. This chart, produced by Dr. Roger Stacey of Nordco, can be used to compare the capabilities of different sensors or sensor combinations to detect ice bergs. The particular graph shown describes the behavior of a standard commercial marine radar. As can be seen, this particular performance is very limited in detecting large icebergs at long range and bergy bits or growlers at short range. This poses severe operational limitations on ships and stationary drilling platforms.

Although difficult to detect, ice impact can be expected to pose severe problems with transitting ships. A Monte Carlo statistical analysis has determined that with a 1% multiyear ice cover a ship has a 100% probability of impacting an ice object in a 100 km undeviated track. This percentage drops to 50% for a 0.1% ice coverage. However, this is a very good indicator that unless there is in existence a very capable ice detection system, frequent impacts with ice are going to be the norm (3).

Collision with any such hazard in excess of 100 tonnes at speeds of 18 - 24 knots could result in at least minor damage to the vessel.

### 2.1.3 Visibility

Available data indicates that, along the coastal areas where offshore operations are likely to be conducted, visibility at times is less than ideal. This complicates the ice detection problem in that it tends to increase the requirements for short-range, high resolution sensors. In the case of a mobile unit, other factors such as rules of the road and a captain's application of common sense will oblige him to slow down if he is travelling at high speed and enters an area of low visibility. If he has access to improved sensors, he may slow down less, thus improving the margin of profit that his ship is operating under.




ICE HAZARD DETECTION
SENSOR PERFORMANCE CHART

FIGURE 2

### 2.1.4 Sea State

With the possible exception of multistatic radar, heavy seas reduce the capability of most sensors to detect hazards, especially those with a low profile. In Arctic regions, sea state is generally of little problem; however, east coast operating areas are much more prone to high seas.

### 2.1.5 Ship Traffic

The following table indicates the shipping traffic expected in the main operating areas.

| REGION | PERIOD | TRANSITS OR INCIDENTS OF SHIPPING |
|---|---|---|
| Gulf of St. Lawrence | Year Round | 2000 |
| Grand Banks | Year Round | Extensive trawling and transit by merchantmen |
| Davis Strait | Year Round | Extensive trawling along coast of Greenland |
| Arctic | July - Sept | 45 in system at any one time |
| | October | 2 to 3 |
| | Nov. - June | 0 |

TABLE 1 SHIP TRAFFIC DENSITY

(Source: Viatec LNG Carrier Tactical Routing Study 1981)

A great concern to the operators of the offshore oil rigs operating in the Hibernia region is the potential hazard for collision with merchant ships. Frequent close calls have indicated a need for some type of vessel traffic management system to alert rig operators of a potential collision. This has been mentioned as a possible capability of an all-round ice and ship integrated detection system.

## 3.0 GENERAL SYSTEM REQUIREMENTS

During discussions with potential operators and consultants a wide range of requirements has been stated. Most operators, with the knowledge of current marine radar capabilities in mind, in particular the associated range and resolution capabilities for other metallic surface contacts, have transferred these requirements to the ice target. Against ice, the capability of achieving these ranges and resolutions with conventional microwave radar is limited. Much work has been done to address this problem and our specification is modelled around these requirements. Most users will admit to wanting to see a tactical or ship/platform mounted sensor with a range capability of approximately 15 - 20 km for large icebergs and progressively shorter ranges for increasingly smaller targets. This is understandable in light of current capabilities. However, at the same time these same operators and consultants will express a requirement for some sort of a strategic system to give them a very long range capability in order that they may carry out longer range planning for ships and platform operations. Before system requirements are further elaborated, definitions of strategic and tactical systems would be useful. Strategic methods of ice and iceberg detection are defined as methods utilized to acquire the ice and iceberg location information, remotely utilizing a sensor platform which acquires the information for the use of other platforms or vessels and does not need or utilize the information acquired for its own internal use.

Tactical systems are defined as systems installed in a platform or vessel, which supply ice and iceberg location information for direct use aboard the platform on which the sensors are located.

One company has admitted that tracking and surveillance of icebergs in the Davis Strait must be conducted on a twenty-four hour basis and include all icebergs within a 32 km radius. Another has stated that a 50 km detection requirement exists for all pieces of ice growler size or larger. Radar and visual sightings are the present means used to attempt to collect this data. However, due to inherent range limitations standby work boats on 'iceberg observation runs' are used to extend the range even further in conjunction with aerial reconnaissance to fill in the gaps out to 32 or 50 km as applicable.

This implies a requirement for a 'strategic' type of iceberg detection. This strategic/tactical concept has been widely developed by most offshore operators including Gulf Oil, Dome Petroleum, Canterra and Viatec in its work for the Arctic Pilot Project. Most strategic systems, however, are extremely expensive and provide a non-real time picture of ice situations. Examples of such systems are airborne synthetic aperture radar, side looking airborne radars and proposed spaceborne systems such as Radarsat. It has been a necessary

component to date because of a simple lack of capability of tactical systems. Thus ice detection requirements fall into either strategic or tactical divisions, and equipment and specifications have been developed to meet these needs. However, with three companies participating in the multistatic radar development, Mobil, Petro Canada and Canterra, there has been a re-evaluation of their tactical and strategic needs. They are developing a tactical system that offers a greatly extended range capability to the point that most strategic systems will be unnecessary.

If this proves to be the case and the multistatic radar is able to significantly improve the radar range and resolution capabilities, the detection range requirements for our specification will change. This is an area that requires continued investigation. The system specification must reflect the operator requirements and if the multistatic system is proven capable of meeting present tactical and strategic requirements in one fell swoop, it should be incorporated into the specification and the requirements changed.

For the purposes of this study, it is included as a sensor option, but stated operator requirements are based on the potential of other available technology. If the range and resolution claims of the multistatic radar developers are indeed correct, then the specification should be changed to reflect these ranges as they are likely to become the accepted standard tactical requirement for future IHD/CAS systems.

Perhaps one of the main findings of this study is that no one sensor will be the answer for all detection problems, nor will any particular combination of sensors suit all user requirements. Overall, there exist three basic system requirements.

The easiest requirement to satisfy would be that system designated for use in a dynamically positioned drill ship. Initial detection of ice hazards should occur at 40 km, either through tactical or strategic means. An ice hazard is defined to be a growler or larger piece of ice. When a potentially hazardous piece of ice closes to 10 km, the rig goes on an ice alert and subsequently drilling stops when ice hazards reach a range of 3 km. When the ice is at a range of 1 km, the rig moves offsite. Because of industry experience in locating and towing icebergs offsite, there has been a build up of a body of qualitative experience as to how well conventional marine radars perform in detecting icebergs. As can be expected, often these radars are totally inadequate and thus improvements in performance for even this most basic system is required.

A stationary semi-submersible drilling platform poses a more difficult problem due to the increased detection ranges required. This increased detection range stems from an increased warning time required necessitated by the extensive amount of preparations involved in moving offsite. In general, a 150 km to 200 km detection range is required. The alert stage occurs at 40 km and drilling stops at 20 km. When ice hazards are within 5 km, the well location is secured and semi-submersible is towed offsite.

A mobile conventional vessel poses the most difficult problem of all. A moving platform requires the longest range detection capability in order to be able to plan its intended track through potentially heavy ice concentrations.

Once in an ice field or fragments of ice fields, a mobile platform would require the most reliable system with the greatest resolution to warn of immediate impact. Of even greater concern would be the danger of impacting large or small chunks of ice due to the difficulty of detection and the higher relative impact speeds.

Table 2 depicts in general terms the requirements for various systems. Included is provision for a sonar which is not included in this specification. It is presented only to outline all of the available options, and assumes that it could play a valuable part of an IHD/CAS. This is not generally supported in the opinion of most operators, and if such a sensor was utilized, thought should be given to integrating it with the remainder of the system.

| | LONG RANGE RADAR | SHORT RANGE HIGH RESOLUTION RADAR | IR | LLLTV | SONAR | CAS |
|---|---|---|---|---|---|---|
| | MASTER SYSTEM | | | | | |
| Large Mobile System | X | X | X | X | X | X |
| Semi-submersible | X | X | Optional (1) | Optional (1) | Optional (1) | X |
| D.P. Drillship | Optional (2) | X | X | X | X | X |
| Mobile Vessel (small) | No | X | X | X | No | X |

TABLE 2 SENSOR COMBINATIONS FOR VARIOUS USERS

As can been seen from Table 2, the master system could fulfill all the lesser requirements through the optional deletion of various components. Note 1 refers to the requirement for IR, LLLTV, and sonar systems on a semi-submersible drilling platform. When it is on station drilling, its requirement for close in ice information is not particularly necessary to determine when to move off site. However, a decision reached to stay on site should a threat be detected by a longer range system and subsequently deemed non hazardous may warrant further monitoring and tracking. This would be required, for instance, if a growler was headed directly for the drilling string and riser under the platform. IR and LLLTV might play an important part in assisting tugs to locate and move these pieces of ice so as not to hazard the drill string.

Note 2 refers to the requirement for a long range detection capability on a dynamically positioned drill ship. Because of the previously stated short reaction time necessary in order to move off station, the dynamically positioned ship would not necessarily require long range information. However, once the ship is in fact underway, it has assumed the status of a mobile platform, with all the attendant requirements. Therefore it is advisable to have a long range detection capability. If this point is kept in mind as well as comments referring to Note 1, then we are faced with a requirement for single master system, with little requirement for alteration to adapt to different operating environments for the majority of users.

## 3.1 System Functional Requirements

The system specification states the technical and functional mission requirements for a system as an entity and allocates requirements to functional areas. The initial version is based on parameters developed during the concept formulation. It establishes the general nature of the system. It shall incorporate system engineering documentation which portrays the items of equipment to be developed. It shall identify the functional areas of the sytem and the individual items of equipment that must be developed or acquired.

## 4.0 PRELIMINARY SYSTEM SPECIFICATION

### 4.1 Scope

Arctic shipping experience has proven a requirement for an improved ice detection capability. East coast offshore operators have also foreseen a requirement for an improved detection system. Concentrations of ice have resulted in lost time for drilling operations and several major ice related accidents have occurred to date, thus Government and oil industry's concern about safety on offshore platforms has forced them seriously consider their options to deal with ice. Environmental consideration will also dictate the need for vastly improved detection and monitoring systems for offshore operations in both the arctic and off the east cost once oil and gas production is underway.

Several studies have been completed recently to address the ice detection problem. Existing sensor capabilities however, without enhancement and system integration are inadequate to meet the needs of a year round arctic shipping system or offshore drilling and production system. There are currently no systems in existence that are optimized for ice hazard detection. Standard marine navigation radar is the only sensor presently being used for the tactical detection of ice. Separate systems exist for electronic navigation which include Loran C and Omega. Various commercial ice motion prediction systems are in use such as those offered by Martec and McElhanney Surveying. None of these systems have been combined to produce an Integrated Ice Hazard Detection/ Collision Avoidance System.

This specification includes the multistatic radar as a component. Although its stated maximum range is 150 km, this range has not been considered reliable enough to include in a specification. For this reason all ranges are based on predicted capabilities of conventional microwave and infrared sensors and not those expected of the multistatic radar. This then will not conflict with the operators requirements stated in Appendix D , which again are based on the capabilities of current systems.

Should development of multistatic radar or any other sensor system progress successfully and its capability prove to be significantly greater than current systems, then the improved range capability should be incorporated into the specification to ensure that these advanced sensors are utilized to maximize IHD/CAS performance and possibly minimize the requirement for external 'strategic' sources of ice information which are currently in use.

## 4.2 APPLICABLE DOCUMENTS

TDC contract 4787. User requirements are contained in Appendix C. Appendix B reviews sensor options. Appendix A contains a Glossary of terms and acronyms.

## 4.3 GENERAL DESIGN REQUIREMENTS

### 4.3.1 Performance

The system must operate effectively in all weather and lighting conditions. This implies uninterrupted coveraged throughout the long arctic night, during periods of extensive cloud cover, ground fog, blowing snow and in other typically unfavorable circumstances. There should be no degradation of performance due to high seas or swell, high winds or sub-zero temperatures. Sufficient redundancy will be available so that the failure of one sensor will not prohibit the acquisition of useful information by the other sensors. To minimize cost there will be no duplication of sensors. Therefore, the system will not be entirely redundant, however information flow to the displays will still be possible with the failure of one or more sensors. The probability of detection of ice will decline however, should either one of the radar's fail, although not to critical levels. The following percentages have been obtained from discussions with operators and are based on currently accepted radar performance for detection and classification of other shipping contacts at sea. With all sensors operating the probability of detection should be 95% for all ice contacts meeting the Arctic Pilot Project (APP) essential requirements listed in Appendix C, Table 1 up to sea state 5. In addition, should the proposed X and S-band or X and ka-band radar combination provide suitable detection capability for land and metallic targets, then it will be possible to install these radars in an IHD/CAS without requiring additional standard marine radars for navigation and collision avoidance with other shipping. Suitable detection range shall be horizon range for shipping and 25 km for medium sized aircraft. Probability of detection of ships and land targets should be equal to standard marine radar performance available from off the shelf units presently on the market, such as the Racal-Decca 2459 F/I combined 3 and 10 cm surveillance radar.

In the case of radars the probability of detection quoted would necessitate a signal to noise ratio corresponding to a gain of 25 decibels. Should one radar fail, the probability of detection should fall no lower than 85% with no reduction in range requirements. Classification by LLLTV and IR systems should be 85% reliable with both systems operational and 65% reliable with one system operational. Initial detection of growlers inside 1 km should occur 95% of the time with IR and LLLTV both working and 75% of the time with one system working only.

### 4.3.2 Maintainability

Maintenance requirements during a voyage or deployment at a well site should not be necessary by the platform crew. All planned maintenance and repairs should be conducted by trained service personnel while the ship is in port or periodically by trained service personnel when equipment is located on a drilling platform. When maintenance is required, and should the skill level of the operator be suitable, it is beneficial that the operator be trained in a first line maintenance capacity. This will enable him to undertake basic diagnostics and repair to board level should a component fail. If this is not feasibile, then a service technician should be available.

An automatic fault locator should be included to enable operators to ensure reliable operation and pinpoint problems areas in the various sensors. Various tests are to be performed on certain sensor modules. The automatic fault locator will fully evaluate all modules found in the IHD/CAS and enable the operator to verify that the system is 100% operational. When a fault is detected, the automatic fault locator shall determine its location and repair should be effected by a serviceman replacing the indicated printed circuit board cards. When repair is affected by the operator or ships/rig technician, sufficient spare circuit boards will be required to be kept on board to facilitate repair.

### 4.3.3 Design Standards

All equipment selected for use should conform to Canadian DOT requirements for marine electronic equipment, meeting the applicable specifications for service conditions, EMI, forbidden parts and materials, mechanical mounting and accessibility, electrical standards and safety.

### 4.3.4 Environmental

All components shall be quiet in operation and immune from specified levels of vibrations, shock, dirt and electromagnetic radiation. Heat emission from all equipment shall be dispersed with appropriate cooling and ventilation equipment to ensure there is no net temperature change caused in control positions by IHD/CAS equipment. Equipment spaces shall be climate controlled including air conditioning and drying agents if necessary to permit safe operation. This should include bridge or control spaces where operator consoles are located.

All outdoor equipment shall be able to sustain -50°C to +40°C temperatures. Indoor equipment shall be able to sustain +5°C to 0°C temperatures. Humidity of 0 percent to 100 percent relative for outdoor equipment and 10 percent to 95 percent relative for indoor equipment shall be tolerable. Operating equipment shall be able to sustain 50 m/sec maximum instantaneous winds.

4.3.5 Power Requirements

Supply voltage shall be in accordance with normally available voltages in civilian ships and drilling platforms. Total power requirements shall not exceed the host vessel's abilility to supply power without modification. If the operator desires, provision should be made for alternate sources of emergency power. The AC Power requirements shall be 50 Hz/60Hz ± 1 Hz and either 115 Volt ±10% 3 phase 4-wire or 240 Volt ±10% single phase 2-wire.

4.4 SYSTEM FUNCTIONAL REQUIREMENTS

4.4.1 System Components

The integrated ice hazard detection and collision avoidance system is a multi-sensor information acquisition and data processing system to detect, track and classify icebergs and ice formation to a degree not previously possible. The major components are the sensors and their associated displays as well as a fully integrated collision avoidance system and ice motion prediction system. The four sensors types to be utilized are a long range high frequency radar, one or more conventional microwave high resolution radars, as well as a low light level television system and an infrared system for close range detection and classification.

The radar sensors will be coupled to a display, to be determined later, and the FLIR and LLLTV camera will be linked via an image enhancer to a Rastor scan display. The type of radar display to be used should be capable of utilizing integration techniques to achieve target enchancement and clutter reduction. Further investigation is required to determine whether a PPI or television display should be used. The individual sensor must have the auto detection capability either inherent, via signal strength, for example, or through processing. The threshold level for auto detect will be set by the operator dependent on ice density and environmental conditions prevailing.

The displays will be able to process the data utilizing sophisticated collision avoidance systems. The collision avoidance system will be capable of auto tracking and computing target information utilizing inputs from the sensor, historical ice data from ice motion prediction systems, ships navigational information and metrological data. The CAS will produce information required to enable the operator to make intelligent decisions regarding rig activity and ship manouevering. The system will be capable of operating automatically with automatic detection capability. The decision to commence auto tracking once a target has been

detected automatically or otherwise should be made by the operator. However, should an operator desire, manual detection by strobing a target can be used with an auto tracking function, or manual plotting may be used. As stated earlier, the master ice hazard detection/collision avoidance system will form the basis for all systems deployed in all vessels and rigs. Figure 3 depicts the ice hazard detection system component blocks and information flow.

The option of deleting sensors should also be available in order to increase the systems utility for small vessels and decrease the cost. Should operators feel that a particular sensor is not required for their applications, then a modular approach to fabrication of components will facilitate this selection.

In addition, with the advent of Radarsat and various sophisticated SAR and SLAR strategic systems, a capability shall exist to incorporate the vast quantities of long range data into the IHD/CAS to insure proper correlation and filtering of pertinent data for the ice observer or ships officer.

Because of the various requirements dictated by the different operating scenarios described earlier, and to enable maximum performance of the IHD/CAS, a modular approach shall be taken. This will enable a choice of sensors and processors to meet the three basic requirements as well as strategic information or more sophisticated iceberg motion prediction and collision avoidance systems.

A capability will also exist to incorporate sonar information when an effective ice detection sonar is developed.

### 4.4.2 System Capability

The overall system functional requirements for an operational IHD/CAS is to provide operators of mobile or stationary platforms with the capability of reliably identifying potential ice hazards, even during extreme environmental conditions, in time to take action to eliminate such hazards.

The ice hazard detection system will be used on a variety of platforms operating in widely variable environmental conditions. It is clear that no single system can economically meet the functional requirements of all potential applications - some degree of specialization is essential. This system specification provides the maximum functional requirements of the principal applications.

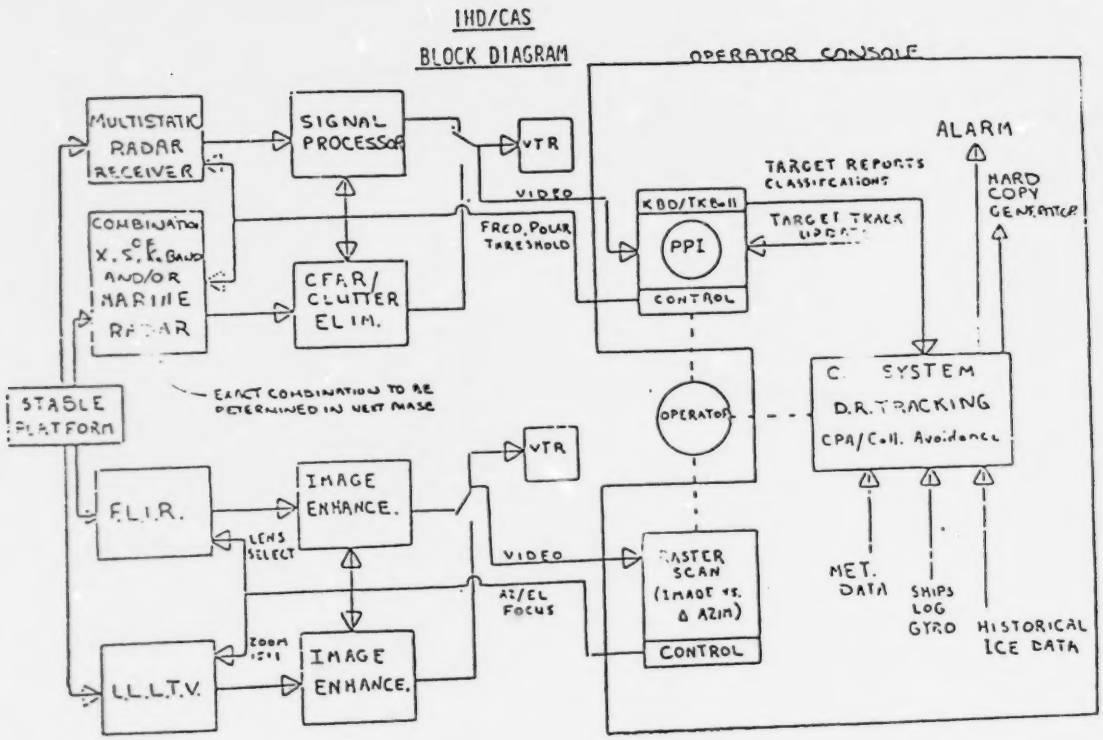



FIGURE 3 - IHD/CAS BLOCK DIAGRAM

Selected sensors are required to scan the region of interest at specified minimum rates, and to detect potential ice hazards at specified minimum ranges with a high probability of detection. The IHDS must track these hazards and predict and display their paths with sufficient accuracy to meet the operational requirements of the platform.

### 4.4.3 Ice Data Requirements

The IHDS prototype system is required to detect ice targets at minimum ranges depending on the nature of the target and its size. These requirements have been formulated in conjunction with arctic and east coast operators and consultants (Table 1). They are based on knowledge and understanding of proposed route conditions, the influence of various ice conditions on predicted ship and oil platform performance and consideration of the rate at which conditions may change.

**TABLE 3**

**DETECTION PERFORMANCE REQUIREMENTS**

| TARGET | WATERLINE LENGTH (m) | HEIGHT (m) | RADAR CROSS-SECTION ($m^2$)* | ENVIRONMENTAL CONDITIONS | | MINIMUM DETECTION RANGE (km) | |
|---|---|---|---|---|---|---|---|
| | | | | SEA STATE | PRECIPITATION | DESIRABLE | ESSENTIAL |
| Iceberg | 100 | 50 | 30 - 60 | | | 20 | 10 |
| Small Berg | 50 | 15 | 10 - 30 | up to: | up to: 16 mm/hr. rain, | 20 | 10 |
| Bergy Bit | 15 | 5 | 1 - 10 | SSS | 5 mm/hr. snow, (equiv.) | 20 | 5 |
| Growler | 5 | 1.5 | .01 - 1 | | Limited visibility down to 100 feet in fog | 10 | 3 |
| Multi-year Floes | 100 - 500 | 2 | | | | 10 | 5 |

*Effective radar cross-section is variable with size, aspect, surface conditions.

The minimum essential detection ranges in Table 3 can be applied to the semi-submersible platform requirements and the mobile vessel requirements which in general possess the greatest ice detection requirements. The dynamically positioned drillship would have lesser requirements for the larger size bergs down to and including bergy bit size. However, the requirements for growler information would remain the same. These detection requirements could possibly be extended with the inclusion of higher performance sensors, such as multistatic radar into an integrated ice hazard detection system.

All of the ice detection parameters listed in Table 4 are important. However, it will be impractical to meet all of the stated requirements at all times and trade off decisions must be made. Accordingly, the ice parameters have been ranked in descending order of priority as seen by the majority of operators. Resolution requirements of each category of ice and priority are listed in Table 4. All resolution requirements and range detection requirements are applicable up to sea state 5 conditions.

### 4.4.4 Frequency of Coverage

The desired frequency of acquisition of integrated imagery is real time coverage.

### 4.4.5 Timeliness

Timeliness is defined as being the delay between the time the data is acquired by the remote sensor(s), and the time the integrated ice formation is available for use aboard the vessel. Again real time coverage is necessary for tactical purposes. Strategic information is required on a minimum of a one a day basis, although more frequent data accumulation may be required under certain environmental or operational conditions.

### 4.4.6 Display Range Capability

Assuming the 150 km capable multistatic radar, the display capability for stationary platforms should extend at least as far as the range of the longest range sensor. IR and TV displays will require displays with a azimuth read-out only. Further investigation to determine a definition of all scales is required. Should a display be utilized to incorporate strategic information, much larger display ranges may be required.

| TARGET | RELATIVE IMPORTANCE | DETECTION | | RESOLUTION | |
|---|---|---|---|---|---|
| | | DESIRABLE | ESSENTIAL | DESIRABLE | ESSENTIAL |
| Very large Bergs | 1 | 20 km | 10 km | all | all |
| Large Bergs | 1 | 20 km | 10 km | all | all |
| Medium Bergs | 1 | 20 km | 10 km | all | all |
| Small Bergs | 1 | 20 km | 10 km | all | all |
| Bergy Bits | 1 | 20 km | 5 km | 8000 $m^3$ (20m sides) | 64000 $m^3$ (40m sides) |
| Growlers | 1 | 10 km | 3 km | 1000 $m^3$ (10m sides) | 8000 $m^3$ (20m sides) |
| Multiyear Floes | 2 | 10 km | 5 km | 100 m | 500 m |
| Multiyear Ridges | 2 | 10 km | 5 km | 1 m | 2.5 m |
| First Year Ridges | 3 | 5 km | 3 km | 1 m height | 2.5 m height |
| Land | 1 | 50 km | 30 km | any | any |
| Leads | 2 | 40 km | 20 km | 100 m width | 200 m width |
| Other Vessels | 1 | 50 km | 20 km | any | any |

TABLE 4 RESOLUTION REQUIREMENTS FOR IIID/CAS

### 4.4.7 Geographical Coverage

Geographical areas of coverage would be limited to the maximum radius of display capability around the platform sensor with the exception of the multistatic radar. In this case, specific sites will be needed to locate the radar transmitters. Coverage will then be a function of transmitter location and ice location. For the case of mobile platforms, accurate assessments will be required of planned routes in order to maximize radar coverage. This will necessitate further study for individual potential users.

## 4.5 SYSTEM INTERFACING

The overall system design must be geared towards modularity in order to achieve the goal of satisfying the maximum number of users with the minimum number of systems. All displays and sensors must be modular in design and construction. Each modular sensor will feed information to an associated processor which will in turn send a processed signal to the appropriate display. There should be two displays, one for radar information and one for IR, LLLTV short range detection and classification information. Processed video information will be fed automatically into the collision avoidance system for auto detect and auto track information handling. Classification should be conducted by human inputs, and then the classified data will be either tracked automatically and handled by convential collision avoidance methods or in the case of ice bergs, an ice motion prediction program will be used.

## 4.6 OPERATOR INTERFACE DEFINITION

This section describes the display requirements on the platform from the point of view of the operators who must either plan an optimum route initially and then modify depending on information supplied by the IHD/CAS or, if the platform is stationary, input ice detection information into an ice motion prediction system for processing. They need a display that clearly presents the essential information without unnecessary detail or coverage of areas not relevant to their objectives. More specifically the master or operator must know where the ice boundaries and individual pieces of ice are. He needs sufficient quantitative information to be able to estimate the difficulty of safely penetrating it or to determine whether it poses a hazard to the drilling platform. The use of television color graphics to replace conventional video presentation for use in most PPI's should be further investigated.

The failure of any one piece of equipment should not cause a loss of information flow. All of the display equipment should require a minimum of operator training. Only one operator per shift will be available for sensor operation, most likely the ice or environmental observer but he could be the officer on watch. The skill level of an operator could be considered high, however, the system must remain simple to operate. The majority of the operators efforts must be utilized to interpret information, not operate the equipment. In case of the officer of the watch operating the equipment, he also will have high skill levels but will probably only be able to dedicate and average of 30% of his time to the system. Shift length will probably be 8 or 12 hours long and thus, acontinuous sensor scanning operation by one operator for this length of time will be virtually impossible. Therefore certain automatic functions are desirable. This will include an auto detect and tracking capability, as stated earlier, alarms for threats and limited input for ice motion prediction computations.

### 4.6.1 Display

This display will provide an output for radar collected data. The displayed information must be simple and uncluttered, clearly visible under all anticipated ambient light conditions and readily understood by a trained ship's officer. A digitized light display is the preferred choice as no hood is required. The repeater display must be located on the bridge. Integration of all radars in the system for display on a common display is required. A true motion and north up display must both be provided for ships underway, while north up only is preferable for stationary platforms. Display aids as follows are required:

1. range/bearing cursor
2. range rings
3. off centering control, up to one radius
4. brightness control
5. video gain control
6. radar selector switch
7. perspex cover c/w parallel index lines
8. position entry device (rolling ball)

Further investigation is required to detemine whether the PPI is the best means of displaying radar data. The possible use of multicolor graphics or multiscaled gray shading should be determined. The objectives of utilizing this type of display would be to improve the detectability of objects located in sea clutter through color shade enchancement. Also the discrimination in sea clutter could be improved. The display should be able to store and replay images, as well as archive data. From studies completed by Gulf Canada Resource

Limited, the following points should be considered for incorporation into the display. First, rather than having the capability for discrete changes of scale, video image zoom and offset display might be considered. Secondly, image storage and recall to enhance ice tracking over a period of time would be beneficial. Remotec Applications is currently investigating improved methods of image processing to enable improved data display and ability to manipulate data.

### 4.6.2 IR & LLLTV Display

This display will provide a field of view about an operator selected bearing on a TV type display for both the infrared and low light level TV sensors. Controls are required for:

1. brightness and contrast
2. image enhancement
3. lens select (IR), zoom (LLLTV), and focus
4. joystick bearing and elevation select

### 4.6.3 Collision Avoidance System

The operator must have the capability of storing and retrieving target data manually or automatically and data must be stored for archival use. The keyboard for accessing these and other data must be part of the operator's console.

The system is required to accept and use a variety of inputs in addition to target data. These inputs include:

1. weather and oceanographic information including surface and subsurface current velocity, wind speed and direction, sea and swell height and direction
2. ship/rig position
3. ice size estimates from visual or secondary sensor information, including height, width, shape, estimated weight and draught
4. ice motion prediction programs
5. a capability to update ice motion prediction information

The system will be required to perform the following functions:

1. auto detect
2. strobe target and initiate track

3. update target position

4. calculate and display target information such as range, bearing, course, speed, CPA and time of CPA for both ships and ice.

5. display trail dots.

6. display CPA vectors, ice calculations would use ice motion prediction techniques

7. datum calculations

8. display danger rings

9. display LLLTV and IR bearing to correlate contacts

Output requirements would be in the form of automatic audio and visual alarms to alert the operator of potential hazards.

## 4.7 SENSORS

### 4.7.1 Radar Subsystems

#### 4.7.1.1 Multistatic Radar

The multistatic radar is a promising sensor now under development for surface mounted long range ice detection. It proposes to have the capability of monitoring both sea ice and icebergs. Ice conditions can hopefully be monitored up to one hundred and fifty kilometers away. If successfully developed it will fulfill the requirement of being simple and inexpensive to operate. It will be capable of receiving and processing clutter free data at the operators location. The system will use high frequency mutlistatic radars. Transmitters would be located on ships, buoys, coastal areas, or other surfaces as required. The transmitter, in conjunction with a receiver at the the user's location would collect data about ice regions and surrounding water for collision avoidance system interpretation and operator use. It would meet the essential ice detection requirements of Table 2. Hardware components would include:

1. transmitter units
2. receiver
3. signal and data processor
4. data recorder
5. display unit
6. system controller
7. 1 to 10 watt power supply

4.7.1.2 Marine Radar

A combined S-band and X-band radar or a combined X-band and Ka-band radar will provide complementary performance against variability in ice target characteristics, propagation paths, and sea clutter. Table 5 summarizes important parameters and characteristics of the marine radars which are considered to have potential for gains in the detectability of ice targets, especially growlers. Depending upon the capability of ice detection optimized radars to detect conventional surface targets, that is other ships, a conventional marine navigation radar may be required. Future field testing will determine the need for this.

Narrow beamwidths and variable polarization necessary for high resolution detectability and all weather sensitivity is required. Furthermore, a roll/pitch stabilized antenna mount could well be required if scan-to-scan processing proves to be needed for enhanced detectability of growlers.

Signal processing is another area requiring attention for detecting small targets in a sea clutter background. The Japanese Radio Corporation offers improved processing capability which warrants further investigation for inclusion in IHD/CAS. Their Sea Ice Signal processor is so designed as to be connected to almost all radar systems. In the absence of other processing systems, the processor should be included when X-band radars are in use. Table 6 summarizes necessary signal processing techniques.

The Sea Ice Signal processor is installed between the radar receiver and a display. The trigger, video and antenna bearing signals are applied from the radar to the processor. The processor performs LPF processing, CFAR processing, sweep correlation processing and scan correlation processing. The results shall be displayed on PPI or colour bright display.

In the case of X-band radar, frequencies different from those of conventional marine radar shall be utilized to avoid mutual radar interference.

4.7.2 Low Light Level Television (LLLTV) Sub System

A large (f. 1.4 or larger) zoom lens (10 to 1 ratio) having a wide field of view will be required on the TV camera in order to provide the necessary sensitivity under low light level conditions. It must be mounted in a stablized, weather-proof enclosure. This enclosure should also house the infrared sensor and lenses.

Processing will be required to enhance the contrast and outline the ice targets and to reduce background noise. Eight TV line pairs is an established criterion for adequate detection and recognition of a target.

| RADAR PARAMETER | PERFORMANCE CHARACTERISTICS/LIMITATIONS | TRADE-OFFS/OPTIONS |
|---|---|---|
| Type: (a) S-band<br>(b) X-band<br>(c) Ka-band | Frequency diversity will provide complementary detection capability against target shape, propagation paths, and noise clutter | X and either S or Ka are required. Possible joint use for ice detection, navigation, and collision avoidance. |
| Antenna<br>(a) Slotted-Waveguide | Rugged, standard, efficient, low sidelobes - difficult to achieve polarization diversity, narrow bandwidth, circular polarization, and narrow azimuth beamwidth. | Must confirm need for variable polarization (V,H); CP is essential. Beamwidth less than .8° (X-band) and less than 2° (S-band) required. |
| (b) Parabolic | Polarization diversity, narrower beamwidths, wider bandwidth; less rugged | May need radome. |
| (c) Phased Array | Polarization and pattern diversity, electronic scanning; narrow bandwidth, grating sidelobe | Costly; stabilization for roll and pitch (if required) is facilitated. |
| Antenna Scan<br>(a) Fixed rate<br>(b) Variable rate | Variable scan rate required for trials; sector scan a definite asset | Final selection may be fixed; range 20-100 rpm needed. |
| Antenna Height/Tilt | Optimization required, adjustable tilt an asset | Height of the two antennas may be different. |
| Transmitter | Power level greater than 30 KW required | May require ± 10% tuning |
| Receivers | Noise figure less than 5 dB (low-noise preamps may be required)<br>Dynamic range greater than 80 dB<br>STC required | |
| Pulse-width | Variable (0.05 to 1 usec) required | Two selections required |
| Pulse repetition frequency | Variable (500 to 4000 PPS) required | Depends on scan rate, beamwidth |
| Signal Processing | CFAR processing is required, Log-FTC, Log-Log; median detector also candidate; separate V and H polarization processing; Multi-scan processing | Level of sophistication to be determined. Stable platform required for scan-to-scan processing |

TABLE 5 MICROWAVE RADAR PERFORMANCE FEATURES

## SIGNAL PROCESSING SPECIFICATION FOR X AND S BAND RADARS

TABLE 6

| | | | |
|---|---|---|---|
| 1. | A/D CONVERSION | | |
| | Resolution | : | 8 Bit in amplitude |
| | Sampling Rate | : | 0.4 us |
| | Number of data samples | : | 1,024 pieces |
| | Processing range | : | 0 - about 33 miles |
| 2. | PRE-FILTER PROCESSING | | |
| | LPF Processing | : | Selectable in steps |
| | CFAR Processing | : | Average value detecting LPF constant selectable in steps |
| | | | Signal delay time selectable in steps |
| 3. | SWEEP CORRELATION PROCESSING | | |
| | Correlation | : | Selectable in steps |
| | Processing Range | : | 1,024 range bins (33 NM) |
| 4. | SCAN CORRELATION PROCESSING | | |
| | Correlation | : | Selectable in steps |
| | Processing range | : | Processing at 8 bit input on 33 miles x 360° |
| 5. | INPUT SIGNAL LEVEL CONTAINING | | |
| | a) Original Signal | | |
| | b) Synchronizing trigger (PRE TRIG) | | |
| | c) Azimuth signal | | |
| 6. | OUTPUT SIGNAL LEVEL | | |
| | Video | : | 1 V Peak |

### 4.7.3 Infrared Subsystem

A sensitive IR emission sensor and special lenses are required in order to provide adequate detection. A liquid nitrogen cooled sensor should not be required, and a pyroelectric TV-compatible device is recommended. A two-lens turrent, mounted in a stablized, weather proof enclosure is required with a viewing window designed to contribute minimal thermal contamination.

Image enhancement processing, which should be common to that required for LLLTV image enchancement, will be needed to increase detectability under fog and rain conditions.

## 4.8. INSTALLATION

Elements of the system requiring care and attention in regards to mounting location include the radar antennas and the IR and LLLTV sensor enclosures.

The height of the radar antennas must be optimized to provide long range (high mounting) sensitivity to sea clutter (low antenna height), and of course avoiding screening due to ship structure. A very similar trade off is also involved in the IR/LLLTV sensor location. Should low elevation mounting of sensors be required to reduce clutter, further study will be necessary to determine whether rig/ship blind spots reported to be up to 40° will necessitate the installation of duplicate sensors to reduce or eliminate these blind spots.

Another consideration in mounting location is that the radar transceivers should be situated reasonably close to their antennas so as to avoid losses in sensitivity due to long waveguide runs.

## 4.9 QUALITY ASSURANCE

Contractors selected for the supply of equipment for development trials should be pre-qualified to establish that they have an established Q.A. infrastructure to ensure quality of delivered documentation and equipment. Features such as the following should be included in the Q.A. requirements on manufacturers:

1. Items are built to specifictions and control drawings which are under configuration control

2. Q.A. requirements are reflected upon subcontractors and vendors

3. Independent conformance checks and acceptance tests done on all deliverables

4. Adequate authority of the Q.A. organization to ensure proper attention at management levels.

## 5.0 FOLLOW ON PROGRAMS

### 5.1 Coordination of Development

In light of the findings made during this study, the construction of an innovative ice hazard detection/collision avoidance system which will be capable of a vastly improved performance over present systems is possible. The greatest development problem is expected to be related to the coordination of all the independent projects to ensure that a common goal is achieved, specifically to ensure that all components of a projected IHD/CAS are capable of being interfaced in order to provide a common readable display, and that each project is conducted in a timely fashion with an IHD/CAS in mind as an end result.

The challenge of detecting ice and using the resulting information in a timely and effective manner is one which is not unique to any particular offshore operator. Virtually all organizations operating offshore have a vested interest in the problem, and thus a cooperative effort is required to find a solution.

This is currently not the case. Most organizations working on the specifics of their own particular needs with little effort being put forth to ensure that their systems will be compatible with others being developed by other organizations. As can be seen from Appendix B, Radar Investigations, a wide variety of programs in various stages of completion are currently underway. It is recommended that one body or organization be appointed to oversee development of all potential sensors to ensure that sensors are developed to interface with and complement each other.

The second problem of significance is that of funding. A wide variety of programs are being undertaken by different agencies and organizations, which are in turn being financed primarily by a variety of government organizations such as the National Research Council (NRC), Department of Fisheries and Oceans (DFO), and the Transportation Development Centre (TDC) and the major offshore operators such as Dome, Gulf, Mobil and Petro Canada. A requirement exists for one organization to take control of financial allocations and ensure all programs are conducted in an orderly manner and reduce the amount of redundancy in the programs being undertaken.

This could perhaps be undertaken as a government/industry cooperative effort, with the agencies involved having a vested interest on the development of an IHD/CAS.

Once individual programs are underway in a coordinated fashion, a testing phase, followed by a field testing phase for all individual sensors should be formulated and conducted. Should the results of the PEX/Remotec Phase II Data Reduction prove useful, this data will prove to be a valuable baseline from which to compare future field testing results.

After field testing has been completed, and assuming that the required sensors exhibit the necessary capabilities to be included in the integrated IHD/CAS, the necessary work should be completed to integrate the sensors and produce a working IHD/CAS, again to be followed with extensive field testing.

## 5.2 Areas of Continued Sensor Development

The recommended development programs to be supported are as follows:

| | Name | Financed By |
|---|---|---|
| 1. | McGill-K-Band Radar Development | NRC |
| 2. | CRL (McMaster) X and K-Band Radar Dev. | NRC |
| 3. | Battelle Institute - Multistatic HF Radar | Canterra Mobil PEX/Viatec |
| 4. | C-Core - CODAR System | Memorial University C-Core Associates |
| 5. | Interra - IDRIS Integration with Sensor Components | McGill |
| 6. | Scannar - Sonar feasibility studies | TDC |
| 7. | Viatec - Specfication Investigation and Data Assessment of an Ice Hazard Detection/ Collision Avoidance System. Overall systems integration including LLLTV and and IR sub-system integration. | TDC |

Also recommended is an evaluation of the Phase II data collected during the PEX/TDC field trials in 1981. This is expected to be completed during a follow-on Viatec/TDC/DSS contract for production of an IHD/CAS specification. Should the data be found useful, it may provide a convenient means of assessing the capabilities of present state-of-the-art and off the shelf equipment.

The last recommendation deals with the use of sonar for ice detection. Currently there are no available underwater means for ice detection. The requirement for such a system has not been advanced and this is probably due to a lack of information and understanding of sonar systems and their capabilities. A program to develop and evaluate an ice detection sonar is encouraged to assess the feasibility of its use for possible inclusion in an IHD/CAS.

For the present time however, this should be considered a separate program due to its relative lack of development to date in comparison with other systems. It should not be expected to be included in an initial version of an IHD/CAS due to its probable difficulty in integration, expected high cost and long development time, as well as a general lack of operator enthusiasm for this particular sensor.

## 5.3 Time Scales and Costs

Order of magnitude costs for these programs are difficult to assess, however an estimate is made here along with projected development times for a variety of programs currently underway.

SCHEDULES AND ESTIMATED COSTS FOR IHD/CAS AND/OR SENSORS CURRENTLY UNDER DEVELOPMENT

A. Mobil Oil Canada Ltd.

| | | COST | TIMESCALE |
|---|---|---|---|
| Phase 1 | Sensor Investigation | .3 Million | 1983 |
| Phase 2 | Sensor Evaluation | 1.0 Million | 1984 |
| Phase 3 | Field Testing | ? | 1985 |
| Phase 2 | System Integration | ? | 1986 |
| Phase 5 | Field Testing | ? | 1987 |

Mobil is also participating in the multistatic radar development. See Appendix D for more details.

B. Petro Canada Exploration

as for Mobil with regard to multistatic radar development.

C. Arctic Pilot Project on hold

D. Canterra Energy Ltd.

as for Mobil with regard to multistatic radar development.

E. Battelle Columbus Laboratories

Multistatic Radar

| | | COST | TIMESCALE |
|---|---|---|---|
| Phase 0 | Bistatic | 85,500 | - Complete 1982 |
| Phase 1 | Multistatic | 171,000 | - Underway 1983 |
| Phase 2 | Prototype | 300,000-400,000 | - 1984 |
| Phase 3 | Field Trials | 300,000-400,000 | - 1984 |
| Phase 4 | Individual user Field Testing | 250,000 | - Est.1984-85 |
| Phase 5 | Production | 200,000 ea. | Est. 1985-86 |

F. Gulf Canada Resources Ltd.

None at present - use conventional marine radar. Looking into SAR. As a partner with Mobil they are financing a portion of the Mobil work.

G. Dome Petroleum Ltd.

A variety of innovative programs are underway with no cost estimates or schedules available.

H. Scannar Ltd.

A Scannar proposal has been submitted to TDC for development of an experimental Sonar.

| | | |
|---|---|---|
| Sonar | 100K | 1983 |
| Interface to Processor | 100K | 1983 |

The extent of field testing has not been determined, however it is hoped that initial field trials will commence during the summer of 1983. Viatec is attempting to arrange a test bed.

I. C-Core

A similar HF radar development program to that of Battelle Institute is in progress. However, unlike the Battelle program, rather than culminating in the production of an operational prototype, this program is geared toward assessing the potential of multistatic surface radars. The level of funding and expected costs of components for the program is very similar to those of Battelle, at least for the preliminary stages of the program. A two station shore based field trial is scheduled in February 1983 to assess the effectiveness of the C-Core developed software in measuring ocean surface currents. C-Core estimates the funds required for a full development to March 1983 total $301,300.00.

## 6.0 CONCLUSIONS

Considerable work remains to be done in the areas of basic sensor research and system integration. Several radar sensors show definite promise for inclusion in the IHD/CAS, and continued support by government and private industry is recommended to develop these sensors on an individual basis.

While this work is progressing, a program should be developed to ensure that the capability of integrating the individual sensors in an IHD/CAS is built into them as they are developed to minimize post-development problems with subsystem interfaces and processing options.

Specification development should continue to a point where hardware items are identified for purchase where possible. Further discussion with operators will be required to continue defining requirements. Should extended range capability become a reality through the multistatic radar or other advanced shipborne radar, these extended ranges should be publicized amongst the operators. If accepted by them, the operators will probably generate new requirements to meet the capability of the radar.

As discussed earlier, such a tactical capability may then supercede the current strategic range requirements and long range ice detection might become possible from the platforms or ships specifically concerned with detection.

## APPENDIX A

### GLOSSARY OF TERMS AND ACRONYMS

| | |
|---|---|
| APP | Arctic Pilot Project |
| CRL | Communications Research Laboratory, McMaster University |
| Bergy Bit | A large piece of floating glacial ice generally less than 5 metres above the sea level, but more than one metre, and normally about 100 - 300 square metres in area. |
| CAS | Collision Avoidance System |
| DFO | Federal Department of Fisheries and Oceans |
| Growler | Smaller piece of ice than a bergy bit, often transparent but appearing green or almost black in color, extending less than one metre above the sea surface and normally occupying an area of about 20 square metres. |
| IDRIS | Interactive Digital Radar Imaging System |
| IHD/CAS | Ice Hazard Detection/Collision Avoidance System |
| IR | Infrared |
| LLLTV | Low Light Level Television |
| Multiyear Ice | Old ice up to 3 metres or more thick which has survived at least two summers. |
| NRC | National Research Council |
| Radar | (radio detection and ranging) - a radio device or system for locating an object by means of electromagnetic transmissions reflected from the object and received, observed and analyzed by the receiving part of the device in such a manner that characteristics such as range and bearing of the object may be determined. |
| SLAR | Side Looking Airborne Radar |
| TDC | Transportation Development Centre |

# APPENDIX B

## RADAR INVESTIGATIONS

## 1.0 INTRODUCTION

This report details inquiries initiated to ascertain what work is being currently undertaken on the subject of surface based radar ice feature detection and classification. These inquiries were restricted to Canadian and American agencies via telephone consultation and in some cases, site visits.

## 2.0 INQUIRIES

### 2.1 Communications Research Center - Ottawa

Contact was made with Mr. D. Selwyn who explained that although CRC had been involved with some ice classification studies, they were not currently active in that area. These studies were undertaken in conjunction with the Department of Fisheries and Oceans and the Communications Research Laboratory at McMaster University. A preliminary report of this study has been acquired although final analysis of the data is being performed entirely by McMaster University.

### 2.2 McGill Weather Radar Observatory

A site visit was made to McGill University on November 2, 1982 where contact was made with Dr. Geoff Austin, the director of the Weather Radar Observatory.

The McGill S-band weather radar has been in operation for about fifteen years. They have developed a sophisticated approach to the analysis and presentation of weather data which is used on a daily basis by the Atmosphereic Environmental Service. Digital processing of the weather data is undertaken to aid in the development for pattern recognition and for tracking algorithms.

In addition to their work in processing, McGill has also done some work in the area of pulse compression via studies with a 32 bit pulse coded wave form. They have done considerable work on the sensitivity of their Decca S-band radar and have managed to increase the overall sensitivity by 26 dB. Also, McGill has done some upgrading of their antenna pedestal and subsequently they have designed and built the pedestal to be used by Goodwood for their Hong Kong weather radar.

The primary reason for visiting McGill was the news that they had received a NRC grant for the development of a Ka-band radar to be used for the open water detection of icebergs. They have some experience in this area via work they did with Dome Petroleum/Remotec on a test bed aboard the Quadra.

Unfortunately, Dome has decided not to release any of the data collected on this experiment to McGill.

Dr. Austin was not prepared to discuss any detailed information on the proposed design of their Ka-band radar and from what can be gathered, the design is in its very early stages. A very general discussion ensued about its probable configuration with the following points having being noted:

- antenna probably parabolic reflector type with very large azimuth aperture and relatively large elevation aperture for high resolution and high gain;
- polarization not critical although vertical linear probable;
- pulse compression probable;
- scan-to-scan integration to be incorporated;
- median, log-log receiver not being considered and are felt not to be required for a proposed digital color display log receiver assumed;
- sector scan recognized to be useful both in terms of increasing sensitivity and reducing sea clutter, however the mechanical strain associated with the large antennas proposed is of concern - some sort of simulated sector scan via continuously rotating antenna with sector-scan-like integration achieved with computer.

No details on the time frame for this development were given and no prognosticated radar performance data was available.

In conclusion, Dr. Austin expressed interest in any future experiments in the area of iceberg detection and offered the use of McGill hardware (such as a 512 x 512 portable display/digitizer) as well as appropriate expertise in exchange for access to the data collected for study purposes.

### 2.3 Communications Research Laboratory McMaster University

A site visit was made to CRL in Hamilton on November 4, 1982. B. Currie, research engineer and T. Greenlay, researcher were contacted. The purpose of this visit was

two-fold. The first was to determine their progress in the analysis of data collected with CRC/DFO at Borden Penninsula in an experiment to analyse the use of a commercially available radar systems for monitoring land-fast ice conditions; and secondly, to discuss their future plans for development of X and Ka-band radar systems using funding from two recently acquired NRC grants.

During the Borden Penninsula experiment, analogue radar video was recorded on CRL's wide-range recorder. Three radar systems were used allowing for evaluation of effects of changing radar frequency, transmit pulse length, antenna beamwidth, polarization, antenna returns. CRC performed some calibration of the radar equipment and also provided hardware and personnel support.

Presently at CRL, the analogue video data is in the process of being digitized for subsequent analysis and comparison to aerial photographs. An interim report on their findings to date is very near completion and is scheduled for presentation at the upcoming POAC conference (spring of 1983).

CRL has recently acquired a Ramtech 9500 high resolution (1024 x 1280) color display which they feel will play a very major role in their system configuration. This display has the capability of being programmed to present any specific color-intensity-saturation scheme. CRL feels that determination of the best color mapping scheme will be a major area for their future research.

As previously mentioned, CRL has very recently been awarded two NRC grants for the development of a X and Ka-band radar system. There was not much specific discussion about the probable design parameters of these experiments although copies of the grant application forms have been forwarded. There were indications that both systems will be high resolution, coherent, polarization diverse instrumentation radar sets. These calibrated radar systems will be used in future ice classification experiments to accurately measure both received power and ice reflectivity. In addition, a Phd. student has been recently added to the staff of CRL whose thesis topic will be the open water detection of icebergs. It is therefore safe to assume that CRL future efforts and developments will include considerations particular to that specific problem.

In terms of future work, CRL will be participating in some additional DFO ice detection/classification experiments in the spring of '83. They will be using the X/S band systems from the previous experiments. As well, they will be renting

two non-coherent systems from Georgia Institute of Technology; a Ka and Ku band system. There were indications that Litton System Canada Ltd. may also be providing support in the form of corporate funding and/or hardware on this next series of experiments.

In conclusion, CRL indicated that they were interested and willing to participate in any future experiments in the area of ice detection by radar. In addition, they expressed strong interest in the data collected during the last TDC/Remotec experiment. The impressive array of experimental equipment and the ability of CRL to raise support and the cooperative nature of their personnel make the Communications Research Laboratory at McMaster University a good candidate for inclusion in any work.

### 2.4 Litton Systems Canada Ltd.

A meeting was held on November 4, 1982 with R. H. McLaughlin, the director of the Radar Systems Group at Litton. At their plant in Rexdale, Litton designs and manufactures a X-band radar system used for airborne maritime patrol.

One of their customers, Greenlandair, uses the Litton APS504 radar system for monitoring the lead edge of the pack ice off the coast of Greenland. They also do some monitoring of iceberg flows although it is not a priority function. The data that is collected is sent to a meteorological agency in Denmark for recording and analysis.

Litton also offers one of their new generation radars, the APS504(V3) aboard a T-com aerostat. This system is being considered for use as a portable coastal surveillance system by the US Coast Guard. The system is capable of operation to a height of 3,000 feet above sea level which greatly improves radar performance in terms of range and grazing angle considerations. This type of approach could be considered similar to that used by Dome whereby an inflatable aerostat is deployed from a ship or drilling platform.

Litton has no immediate plans to get into the maritime radar business. However, their future development plans include a coherent transmitter with a 30 nanosecond pulse compression capability as well as an upgraded display subsystem.

## 2.5 Battelle Columbus Laboratories

Battelle is developing, for a group of three oil companies, a new high frequency multistatic radar system. It is an all weather high resolution surface to surface system with data processing and display located at the user's site. The major advantages of the system will include extended detection ranges (up to 150 km), enhanced signal return (high S/N), free of clutter associated with conventional microwave radars. No special skills will be required for interpretation.

Previous activity has consisted of techniccal and operational tradeoffs using aircraft, helicopter and surface platforms. The present activity at Battelle centers on producing a prototype hardware design of the multistatic surface to surface radar system. Once the design has been completed a prototype will be constructed and tested in the laboratory and then in the field.

## 2.6 Intera Environmental Consultants

Intera's primary interest is in the area of airborne sensing using UV, IR, SAR, and SLAR techniques. Their past application include forest fire mapping, iceberg decay studies, etc., plus broad experience in shipborne remote sensing of ice and in particular, display techniques.

Intera manufactures a display system called IDRIS (Interactive Digital Radar Imaging System) which is made up of a radar interface, a small computer (PDP 11/23) with standard disk and tape drives and a high quality video display system. This sytem was developed in conjunction with McGill University. IDRIS is used for data logging and display plus target tracking and data recording. Intera has customers for this display system operating in the Beaufort and Alaska waters. IDRIS is to be used in conjunction with upgraded marine radar systems on drilling rigs.

Dr. Lowry made comments about Dome's T-Com aerostat experiments with a Decca radar onboard deployed from ships or rigs. Apparently, Dome had a one year contract with an option for an additional year. They did not exercise their option.

The subject of sea clutter was discussed in some detail. Particularly, we discussed the probability density function associated with sea clutter on a high resolution radar system. I stated that there seemed to be a great deal of ambiguity about which pdf was appropriate to describe this type of sea clutter. Dr. Lowry countered with the statement that the so-called k-distribution suggested by Eric Hakeman was in his opinion the best pdf. He went on to say that some

form of scan-to-scan integration such as that implemented in their IDRIS system was the most promising for reduction of sea clutter.

In conclusion, Intera is primarily interested in proposing their airborne SLAR system for iceberg monitoring. However, the IDRIS display/processing system would be worth further investigation for inclusion in the IHD/CAS configuration.

## 3.0 CONCLUSION

This study has been undertaken to investigate current activity in the area of iceberg detection by surface based radar.

Based upon discussions and readings so far, the best candidate for a surface based high resolution iceberg detecting radar system would appear to be an X/Ka band radar, possibly coherent with a high resolution digital display capable of scan-to-scan integration, sector scan and other processing techniques yet to be specified. This radar would be used in conjunction with an HF multistatic radar for long range, lower resolution detection. Although such a system does not presently exist, there are agencies active and willing to participate in a development program. If the efforts of all participants could be properly focused on one area, a good iceberg detecting radar system could become a reality.

# APPENDIX C

## USER REQUIREMENTS

September 22, 1982

Results of a Discussion With the Arctic Pilot Project Group Concerning TDC Contract 4787 held 21 September 1982.

Ref: 1. Transporation Development Center Service Contract 47
2. VIATEC Resource Systems Inc. LNG Carrier Tactical Routing System Study Final Report 28 October 1981.

In order to meet the specific objective of TDC contract 4787, Viatec has been tasked to conduct discussions with organizations involved with Arctic and/or Northern water operations. These discussions are to focus on the functional and operational requirements of a proposed Ship-borne Ice Hazard Detection/Collision Avoidance System. The opinions are those of the APP group with regard to their particular requirements as well as those of Dome and Melville shipping general requirements for large ships.

In attendance at the discussion were the following:

1. M. McKinnon Viatec Resource Systems Inc.
2. M. Harvey Viatec Resource Systems Inc.
3. R.W. Lumsden Manager, Shipping Dome Petroleum Ltd.
4. B. Dixit Manager, Environmental Engineering, Melville Shipping Ltd.

The APP group has recognized the need to develop an improved capability to detect, track and avoid ice hazards of all types in Arctic and Northern waters. The APP tactical routing system study conducted previously was an effort to come to terms wih this problem. The basic requirements of such a system have not changed in the little time that has elapsed since the completion of the study. Therefore our discussion with the APP was centered on their previously defined requirements.

The sensor options of radar, LLLTV and IR detection systems remain the most favoured. There is considerable doubt on the part of the APP group of the feasibility of using a shipborne sonar system.

The primary concern of APP group is that whatever system is developed, it be easily operated and capable of reliable, trustworthy operation. During ice-transiting operations, it was pointed out by the APP group, the intensity of operations is extreme and the demands placed on ships officers was great. Their time available to tinker with complex sensor operating systems is non-existent. They must be provided with displays that are easily manipulated and conform to accepted standards of operating complexity. If the system is a burden to operate, it will simply be ignored. The same result will occur if the system is unreliable. The system as a whole must perform well under all environmental conditions. In addition to these two constraints, a third was added by the group. They stated that the ship's bridge watchkeeping officer would be the prime operator. Perhaps one sensor operator would be available, however there is no planning at the present time for a large complement of sensor operators and maintainers to be made available. Therefore, it is very important to produce specifications that will call for an integrated, automated display.

The APP group recommends the use of several radars and several displays. Because radar is the traditional marine navigation hazard sensor, they feel it should remain as such. However they are of the opinion that two of the radars, preferably a 3 cm and a 10 cm set should be optimized for ice detection and not ship/land hazard detection. They do not feel that radars produced to date are effective in this regard and desire a major improvement in radar detection threshold performance. They are not too particular about how this is accomplished, but they have determined that improved performance is a requirement. The third radar would be an up to date off the shelf marine navigation radar for routine ship detection and avoidance. The APP group believed that each radar should have its main display so that the ships officers could usually compare each radar's performance and select the radar which was performing the most effectively under a given set of conditions. The radar displays should be easily operated with a minimum number of fine tuning options. Once the best radar presentation is chosen, the capability should exist to remote the signal to the main operating console where an installed Collision Avoidance System is integrated with the selected radar presentation. The collision avoidance system should be automatic, and once a target is designated a threat, there should exist an automatic tracking capability with an output of range bearing and closest Point of Approach. An automatic alarm system is desirable.

The LLLTV and IR sensors are considered important, however the APP group considers them to fulfill a supporting role in which they supplement radar information to confirm a radar contact. They too should be co-located with the radar/collision avoidance system and be easily operated. Their output should be composite video presentation on a TV monitor with azimuth information supplied. All displays including radar should be readable under all ambient light conditions.

The Arctic Pilot Project group were skeptical of the use of an active, hull mounted or variable depth sonar for two reasons. Firstly, it would be very susceptible to damage in an ice environment. Any safe location for mounting on board a ship would probably reduce its detection capability to the point of eliminating any possible effectiveness. Variable depth sonars would probably be lost repeatedly through the severing of the cable. The second problem involves the requirement for interpretation of sonar information. While an experienced sonar operator may be effective in using a sonar to the point of being able to interpret and analyze data to come up with a threat evaluation, a ship's officer would not have the time, particularly during operations in ice infested waters.

This system then would require the use of dedicated sensor operators who would feed data to ships officers or perhaps into the Main operating console through the use of an installed target plotting attachment where the sonar contacts could be plotted and compared with other sensor information. The APP group feels that this is a rather complex situation and perhaps not practical considering manpower requirements. However they do believe that further research is required in the use of sonar in non military applications.

Detection criteria for LNG carriers remain unchanged from the tactical routing system study. Although demanding they are felt to be necessary. See Table 1.

The APP group did not seem overly concerned with price, but more interested in producing a workable, easily operated system using advanced technology. They stressed the requirement for improved performance from ice detection radars. They are eager to see a production system in existence by 1987.

| Target | Relative Importance | DETECTION | | RESOLUTION | | Other Notes |
|---|---|---|---|---|---|---|
| | | desirable | essential | desirable | essential | |
| Very large bergs | 1 | 20 km | 10 km | all | all | |
| large bergs | 1 | 20 km | 10 km | all | all | |
| medium bergs | 1 | 20 km | 10 km | all | all | |
| small bergs | 1 | 20 km | 10 km | all | all | |
| bergy bits | 1 | 20 km | 10 km | 8000 $m^3$ (20m sides) | 64000 $m^3$ (40m sides) | |
| growlers | 1 | 10 km | 3 km | 1000 $m^3$ (10m sides) | 8000 $m^3$ (20m sides) | |
| multiyear floes | 2 | 10 km | 5 km | 100 m | 500 m | |
| multiyear ridges | 2 | 10 km | 5 km | 1 m | 2.5 m | |
| first year ridges | 3 | 5 km | 3 km | 1 m height | 2.5 m height | |
| land | 1 | 50 km | 30 km | any | any | |
| leads | 2 | 40 km | 20 km | 100 m width | 200 m width | |
| other vessels | 1 | 50 km | 20 km | any | any | |

TABLE 1 - APP IHD/CAS DETECTION REQUIREMENTS

September 29, 1982

Results of a Discussion with the Gulf Canada Resources Concering TDC Contract 4787 held 28 September 1982.

Ref: 1. Transporation Development Center Service Contract 4787
2. VIATEC Resource Systems Inc. LNG Carrier Tactical Routing System Study Final Report 28 October 1981.

In order to meet the specific objective of TDC contract 4787, Viatec has been tasked to conduct discussions with organizations involved with Arctic and/or Northern water operations. These discussions are to focus on the functional and operational requirements of a proposed Ship-borne Ice Hazard Detection/Collision Avoidance System.

In attendance at the discussion were the following:

1. M. Harvey — Viatec Resource Systems Inc.
2. Michael To — Project Engineer, Gulf Canada Resources
3. Joe Eley — Ice Surveillance Group, Gulf Canada Resources

Gulf Canada Resources currently has in-house an Ice Surveillance Group which is tasked with strategic and tactical ice detection and prediction of ice movement. The primary reason for concern in this regard is the vulnerability of their drilling platforms, in particular the first unit, which is different in design from their second unit and also different from other drilling units located in the Arctic and Canadian East Coast. A secondary requirement for IHD/CAS is for subsequent production platforms and Gulf's support vessels.

Their current approach to ice hazard detection is to use an airborne SLAR radar which would make periodic trips over the area of concern, probably once every two days or so and then use a path prediction system to calculate drift towards the drilling platform. If necessary support vessels would be dispatched to move potentially dangerous pieces of ice. This system concept is sound in theory, but would present problems in reality.

When ice conditions are at their worst, which would easily occur when meteorological conditions are bad, the requirement for reliable ice hazard detection would be at its greatest. Yet in all probability, aircraft would be grounded.

The system would also be extremely expensive, and as stated earlier, would necessitate only periodic coverage. The gaps in time would therefore need to be covered with a pre-programmed ice movement prediction system which would produce general ice motion information. This information might be useful if there were only a few pieces of ice, but if there are many the value of such a system in predicting which piece of ice would be a hazard to a drilling platform might be hard to determine.

Therefore, Gulf sees a definite requirement for a tactical ice monitoring system. However, unlike PEX, Canterra and Mobil, they have no programs underway at present to come up with an improved ice detection system. Their present solution is to utilize off the shelf marine radars with the possibility of using improved processing capability. They do not believe that this will be the answer to the problem and wish to participate in a program designed to improve detection capability. Their main concern with ice is multiyear ridges greater than 100 square meters in area. This ice is felt to be the main hazard to their drilling platform. For this reason they would like to see detection ranges of 30 km for multiyear ice in first year ice.

Other than this rather stiff requirement their needs fall within those of the Tactical Routing System Requirements for the Arctic Pilot Project. They also would like to see an integrated ice movement prediction system.

The prime sensor of interest to Gulf is Radar. They are skeptical of any new developments for an ice optimized radar, but are aware of the development of the multistatic radar by Dr. George Mourad of the Battelle Institute. They are interested in pursuing the feasibility of using this radar in an integrated system, but currently are not involved with the project.

When asked about their interest in utilizing other sensors, they replied that no thought had really gone into using them, but proposals would be welcomed. Sonar was ruled out due to manning and reliability problems. They felt that any sonar information that was supplied would be ambiguous and not really of much use.

If an IR or LLLTV system was supplied, it would have to integrated with the radar and easily operated. They could not be more specific than that.

They were specific about their manpower requirements. The entire system would have to be operated by one man, perhaps not even a specialist sensor operators, but one of the platforms technicians. Therefore a system, if it did use more than a single sensor radar, would have to be a completely integrated, one console station, with an installed collision avoidance system. Where possible, target information should allow the target to be recognized or identified. This may necessitate visual imaging displays. This might help distinguish between multiyear ridges and first year ice. It would need to be able to provide automatic detection warning

of hazards. These hazards would require automatic tracking with minimum user input combined with a real time prediction system using environmental and oceanographic input to determine the potential hazard of the contact. There was no particlar requirement to tie in this ice information with a standard marine radar, although it would be a possible option for them.

The system shall operate in all light levels and all meterological conditions with no degration due to precipitation and blowing snow.

A system acceptable to Gulf would have to be moderately priced in relation to a cadillac system that the Arctic Pilot Project might be prepared to afford. If a low priced system was available and significantly better than those currently available, Gulf would consider installing them on support vessels.

Their initial requirement is for a system to be in place by the fall of 1983 when their first drilling platform is scheduled to become operational. However, this requirement is about to be filled with an off the shelf radar and display with improved processing or display capability. The next requirement would be for a system to be installed on a production facility in the mid to late 1980's. Gulf is leaning towards pipeline transport of crude oil and does not feel that the system would be requireed for conventional oil tankers operating in the arctic, although this could change depending on Dome's approach , which supposedly is one of using tankers. Gulf wants to wait and see the results of the APP before committing themselves to a tanker development program.

As stated earlier however, they are interested in pursuing development of an improved ice hazard detection system with particular regard to sensor improvement.

| Target | Relative Importance | DETECTION | | RESOLUTION | | Other Notes |
|---|---|---|---|---|---|---|
| | | desirable | essential | desirable | essential | |
| Very large bergs | 3 | 20 km | 10 km | all | all | |
| large bergs | 3 | 20 km | 10 km | all | all | |
| medium bergs | 3 | 20 km | 10 km | all | all | |
| small bergs | 3 | 20 km | 10 km | all | all | |
| bergy bits | 3 | 20 km | 10 km | 8000 $m^3$ (20m sides) | 64000 $m^3$ (40m sides) | |
| growlers | 3 | 10 km | 3 km | 1000 $m^3$ (10m sides) | 8000 $m^3$ (20m sides) | |
| multiyear floes | 1 | 30 km | 20 km | 10 m | 100 m | |
| multiyear ridges | 1 | 30 km | 20 km | 1 m | 2.5 m | |
| first year ridges | 2 | 5 km | 3 km | 1 m height | 2.5 m height | |
| land | 3 | 50 km | 30 km | any | any | |
| leads | 3 | 40 km | 20 km | 100 m width | 200 m width | |
| other vessels | 3 | 50 km | 20 km | any | any | |

TABLE 2 - GULF IHD/CAS DETECTION REQUIREMENTS

September 30, 1982

Results of a Discussion with Canterra Concerning TDC Contract 4787 held 29 September 1982

Ref: 1. Transportation Development Center Service Contract 4787.

2. Viatec Resource Systems Inc. LNG Carrier Tactical Routing System Study Final Report 28 October 1981.

In order to meet the specific objective of TDC contract 4787, Viatec has been tasked to conduct discussions with organizations involved with Arctic and/or Northern water operations. These discussions are to focus on the functional and operational requirements of a proposed Shipborne Ice Hazard Detection/Collision Avoidance System.

In attendance at the discussion were the following:

1. M. McKinnon Viatec Resource Systems Inc.
2. M. Harvey Viatec Resource Systems Inc.
3. Howard Westergard Senior Engineer New Development, Canterra

Although they are partners with Mobil and Petro-Canada, involved with the development of the multistatic radar at the Battelle Institute, their participation seems limited to assuming responsibility for part of the funding of the project with little engineering or operational input going into the system.

Their focus of operations was shifting towards offshore Nova Scotia and away from the Davis Strait, thus reducing the immediate requirement for any sort of sophisticated Ice Hazard Detection/Collision Avoidance System.

Their operations to date in the Davis Strait area have not been without their problems, however they considered downtime of the rigs due to ice problems to be in the order of one per cent. This was a sufficiently small fraction of total operating time to not really warrant further development of ice management or detection system.

Ultimately, if production facilities are installed in the Davis Strait vicinity, there would be a requirement for improved IHD/CAS capabilities. This is low on Canterra's priority list however, they might be interested in small scale funding for sensor development. Their specific requirements for ice hazard detection systems are not defined. Whatever the drilling contractor supplies is fine as long as it meets government regulations.

The primary sensor is radar and no integration with other sensors was seen as a requirement. An up to date integrated display was not seen as a valuable tool. The Canterra view of ice prediction systems is that they are no good. The only desirable functional requirement of any system development would be to try and obtain a 15 km detection range for growlers. This is rather optimistic but would give Canterra adequate warning time to conduct an orderly move off location should ice pose a threat. This was based on a 1.5 knot current and a 5 hour lead time to move off.

October 7, 1982

Results of a Discussion with Mobil Canada Concerning TDC Contract 4787 held 6 October 1982

Ref. 1. Transportation Development Center Service Contract
2. 4787 Viatec Resource Systems Inc. LNG Carrier Tactical Routing System Study Final Report 28 October 1981.

In order to meet the specific objective of TDC contract 4787, Viatec has been tasked to conduct discussions with organizations involved with Arctic and/or Northern water operations. These discussions are to focus on the functional and operational requirements of a proposed Shipborne Ice Hazard Detection/Collision Avoidance System.

In attendance at the discussion were the following:

1. M. Harvey Viatec Resource Systems Inc.
2. M. McKinnon Viatec Resource Systems Inc.
3. Jacques Benoit Mobil Oil

Mobil is currently undertaking extensive studies in the area of ice hazard detection. They are currently in the process of looking at a wide range of sensors and sensor systems and the cost/benefit advantages of each one. Shortly they will be entertaining proposals for an extensive study comparing capabilities and limitations of different sensor combinations and approaches. In cooperation with Petro-Canada and Canterra Energy, they are undertaking a study conducted by the Battelle Institute to develop a multistatic High Frequency radar system. This radar is projected to have a capability to make initial detection of large pieces of ice to ranges of 150 km. Resolution will be 10 x 10 m at 5 km. This confirms suggested APP requirements. They are not sure if this is the answer to their ice detection problems, they only feel that it may be a possible solution. They are of the opinion that advanced signal processing of radar signals on a standard marine radar may be a cheaper alternative than large development programs. Therefore they are also looking into possibilities offered by the Japan Radio Corporation (JRC) through its capabilities to produce such a system.

Jacques Benoit, a Mobil Oceanographer, has the opinion that ice detection and prediction is a minor problem compared with other environmental problems. Therefore while they are interested in exploring all the options available, they may select an inferior system if it gives the most value for their money. Conversely, if an expensive system produce extremely good results this may be the system they select. Therefore until they have seen a study outlining all the options, they will not specify what particular sensors they want, nor will they specify the degree of sophistication required in individual sensors or the amount of integration necessary. A larger concern to Mobil than the ice detection problem is the shipping concentration in the Hibernia region.

Therefore they see a distinct need for a radar capable of good marine performance with an excellent anti-collision warning system. This type of radar is already in existence. Mobil was not concerned with large icebergs as much as growlers. This would indicate a requirement for short range, high resolution systems.

Other Mobil interests lie in the areas of Synthetic Aperture Radars, Codar, sonar systems, LLLTV and IR systems. Again they require more information on these systems before they make any decisions on which ones they want to see in a system. Also they wish to see improvements in a given available system through the use of low noise amplifiers, combining X and S band inputs and even simply location improvements such as utilizing the top of the drilling mast on a platform rather than installation at a lower elevation.

In summation, Mobil wants more investigation completed on sensor capabilities before they commit themselves to selection of specific units of hardware for systems integration.

# APPENDIX D

# REFERENCES

## REFERENCES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POOR

QUALITY

ORIGINAL